Space Weather Technical Forecast

Issued on Monday, 08 May 2023 at 13:35 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: S1/Minor Proton storm expected 08-09 May. G1/G2 (Minor-Moderate) Geomagnetic storms likely 10-11 May with a slight chance of G3/Strong storms. Further R1-R2 Radio blackouts expected.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate with the largest flare a long duration event peaking at M1.6 at 07/2323 UTC from AR3296. This was the only M-flare during the period. There are a trio of spot groups spanning the northeast to northwest centre disc: AR3293, AR3296 and AR3297. All appear to be magnetically linked. AR3297 just east of the Earth-Sun line in the northern hemisphere is the largest and most complex region with a large mature positive polarity spot between two areas of smaller negative magnetic field. AR3296 a compact, anti-Hale cycle (reverse polarity) region to the west has shown some growth in the trailing portion of the group. A delta spot may be in the formative stages of development towards the intermediate part of the region. AR3293 in the northwest appears to be simplifying somewhat, with a reduction in size evident from recent coronagraph imagery. All other regions appear simple and stable at this time. In total there are five numbered and one unnumbered sunspot groups on the visible disc.

A full halo CME was associated with the M1.6 flare from AR3296. Although much of the ejecta appears to be directed to the northwest an Earth-directed component is expected and has been modelled.

Solar Wind / Geomagnetic Activity: The solar wind was initially slightly elevated, near 400km/s but increased to around 450km/s from 07/1445 UTC with the arrival of a CME at L1 that left the sun on 04 May. Solar winds erratically increased further during the period to generally 450-500km/s with a peak speed of 546km/s at 07/2047 UTC. Speeds have remained elevated to slightly elevated since, with another CME arrival likely to have occurred at L1 at 07/2330 UTC. There is also a possibility that a High-Speed Stream from CH01/+ was embedded in the solar-wind. Density was above average with a peak of 40 ppcc around 07/1442 UTC with the arrival of the aforementioned first CME. Density eased thereafter, remaining above average at first but becoming average from around 08/0430 UTC. Total IMF strength, Bt, was initially weak before increasing to Moderate to Strong with the first CME arrival, reaching a peak of 20 nT around 07/1500 UTC. Following this the Bt eased, becoming generally Moderate and then later Weak after approximately 08/0300 UTC. The north-south, Bz, component was largely positive, but with isolated deviations to negative, varying between +15nT and -14nT. Phi angle was mainly positive (away from the Sun). Resultant Geomagnetic activity was Quiet to Active (Kp2-4).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) as measured at GOES16, has remained below the S1/Minor storm threshold, although >10MeV flux levels are above background levels and currently just below the S1/Minor storm level on an increasing trend. High energy electron flux (greater than 2MeV) as measured at GOES16 has been at mainly background levels. The 24-hour integrated fluence has been well below Active levels with recent geomagnetic activity having reduced electron counts. At 08/0000 UTC 1.53e6 integrated pfu was recorded.

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Met Office Space Weather Technical Forecast

Four-Day Space Weather Forecast Summary

Solar Activity: Isolated Moderate activity, with a slight chance of Strong activity is forecast through the next four days, mainly from the regions in the northeast to northwest centre disc.

Solar Wind / Geomagnetic Activity: A full halo CME was observed in coronagraph imagery with the M1.6 flare from AR3296 at 07/2323 UTC. Although much of the ejecta appears to be directed towards the northwest an Earth-directed component is expected and has been modelled to arrive at Earth either on late 10 or early 11 May.

Earth may be under the influence of one or more HSS from coronal holes in the sun's western hemisphere, although this is somewhat uncertain given the recent enhancements to solar parameters due to the arrival of multiple CMEs in the past 24 hours. Elevated to slightly elevated winds should ease to background either on 09 or 10 May as the influence of the coronal hole(s) and residual CME effects wane. Some enhancement in the solar-wind may occur late on 11 May due to a coronal hole currently approaching the meridian in the northeast. Any impacts are expected to be weak based on persistence, but are more likely to be masked by the expected arrival of the CME that left the sun on 07 May, either late 10 or early 11 May. Solar winds are most likely to increase to elevated levels with the CME bringing an increased risk of significant geomagnetic activity.

On 08 and 09 May Quiet to Unsettled activity is expected with a slight chance of isolated Active intervals (08 May only). Quiet activity on 10 May should become G1-G2 (Minor to Moderate) storm conditions either late on the day or early 11 May, with a slight chance of G3 (Strong) geomagnetic storm levels being reached.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to exceed the S1/Minor Storm threshold on 08 and early 09 May before returning to ambient or near background levels in the absence of any further significant flares. High energy (greater than 2MeV) electron flux is expected to persist at mainly background levels, with a possibility of reaching diurnally High levels on 10 May ahead of the anticipated CME arrival either late 10 or early 11 May. The associated 24 hour fluence is forecast to persist below the Active threshold.

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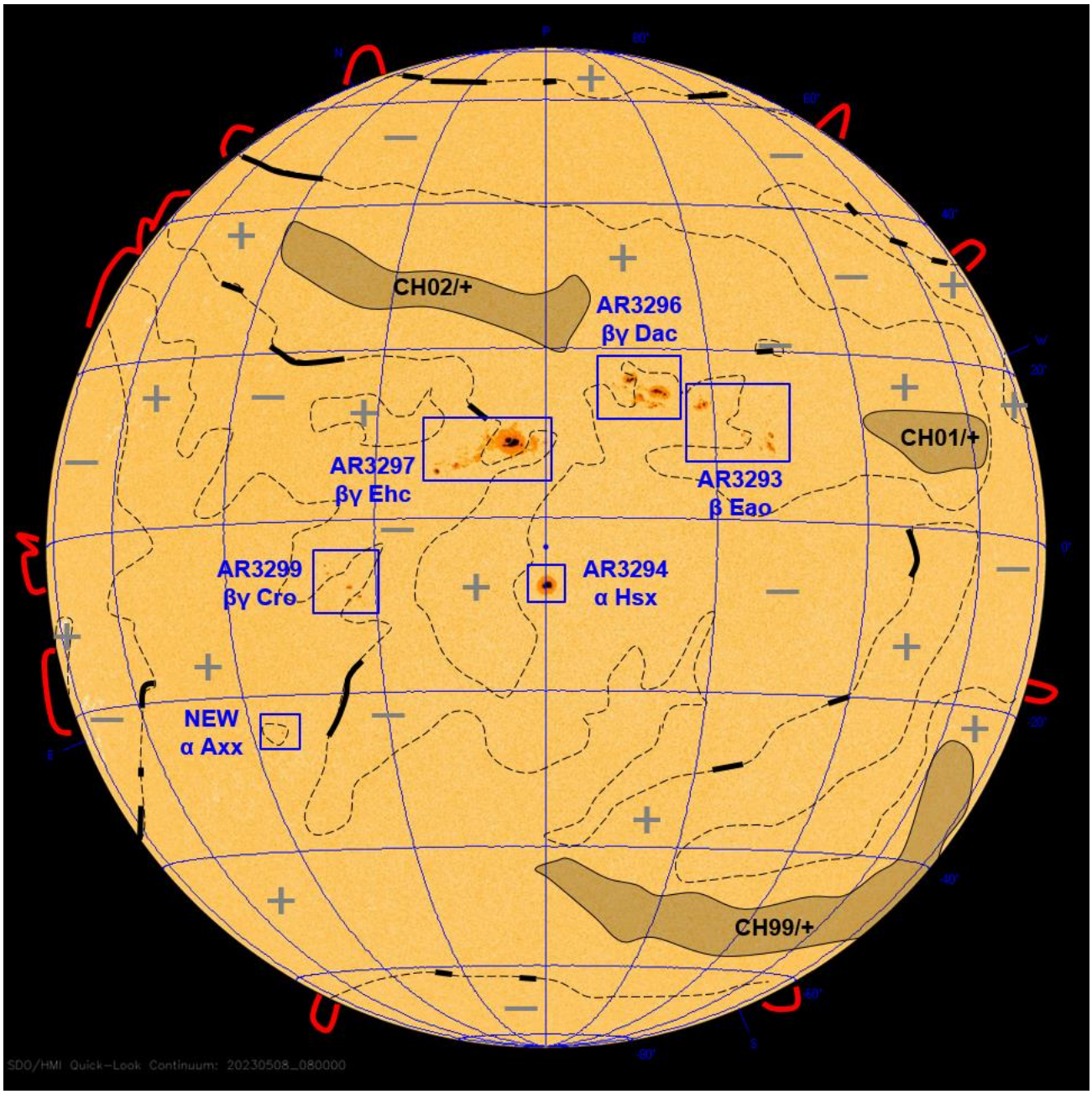
Figure 1. Solar Analysis Valid 08/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

Two CMEs that left the sun on 04/05 May arrived at Earth as forecast around 07/1445 UTC and 07/2330 UTC. In general the geomagnetic response to this was largely muted given persistent periods of mainly positive Bz associated with these features.

A full halo CME was observed in coronagraph imagery with the M1.6 flare from AR3296 at 07/2323 UTC. Although much of the ejecta appears to be directed towards the northwest an Earth-directed component is expected and has been modelled to arrive at Earth either late on 10 May or early 11 May.

Earth may be under the influence of one or more HSS from CH99/+ and/or CH01/+, although this is somewhat uncertain given the recent enhancements to solar parameters due to the arrival of multiple CMEs in the past 24 hours. Elevated to slightly elevated wind should ease to background either on 09 or 10 May as the influence of the coronal hole(s) and residual CME effects wane.

Some enhancement in the solar-wind may occur late on 11 May due to CH02/+ currently approaching the meridian in the northeast. Any impacts are expected to be weak based on persistence, but are more likely to be masked by the expected arrival of the CME that left the sun on 07 May, either late 10 or early 11 May. Solar winds are most likely to increase to elevated levels with the CME bringing an increased risk of significant geomagnetic activity.

On 08 and 09 May Quiet to Unsettled activity is expected with a slight chance of isolated Active intervals (08 May only). Quiet activity on 10 May should become G1-G2 (Minor to Moderate) storm conditions either late on the day or early 11 May, with a slight chance of G3 (Strong) geomagnetic storm levels being reached.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	1	80	80
Strong	G3	No	1	1	10	10
Severe	G4	No	1	1	3	3
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
08/0300	Full	Flare	AR3296	950km/s	10/2100 UTC +/- 9 hours	N/A

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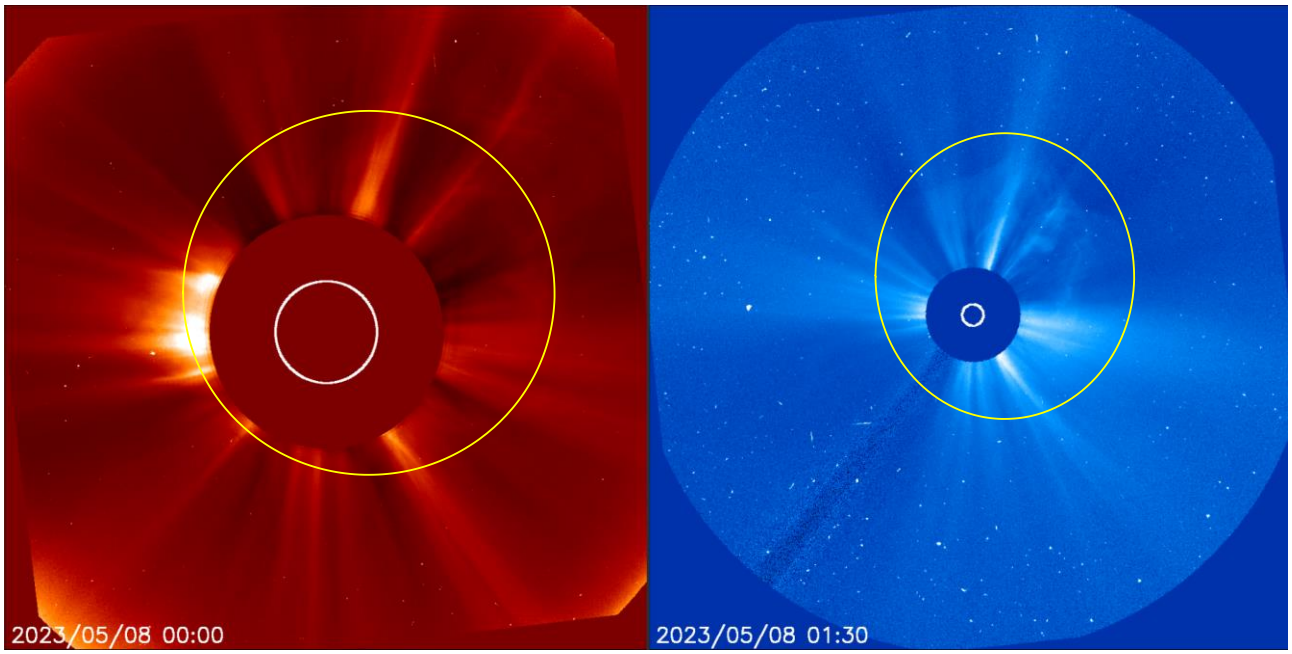
Figure 2: LASCO C2 (left) and C3 (right) imagery from 07 May CME. CME circled in yellow.



Radio Blackouts - X-Ray Flares:

Isolated Moderate activity is expected to continue, with further M-flares likely and a slight chance of isolated X-class flares.

Significant flare activity in the coming days is most likely to occur from the three magnetically interconnected sunspot regions across the northern disc. The largest and most complex of these is AR3297 (Ehc/Beta-Gamma) in the northern hemisphere approaching the Earth-Sun line. It possesses a large mature positive polarity spot between two areas of smaller negative magnetic field. AR3296 (an anti-hale cycle, reverse polarity spot) to the west appears magnetically linked to AR3297 and has shown some growth in the trailing portion of the group. A delta spot may be in the formative stages of development towards the intermediate part of the region, but for now a Dac/Beta-Gamma magnetic configuration is attributed to the area.

AR3293 (Eao/Beta) in the northwest appears to be simplifying somewhat, with a reduction in size evident from recent coronagraph imagery. All other regions appear simple and stable at this time.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	70	70	50	50
Very Active	R3 to R5 X Class	No	10	10	5	5

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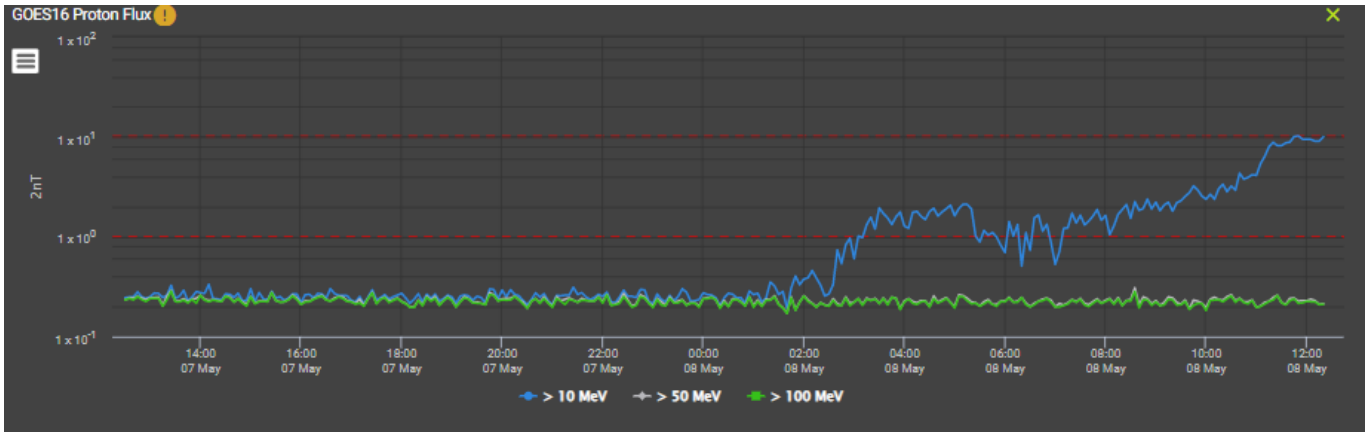
Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux as observed by GOES-16 has been increasing, likely in response to the long-duration M1.6 flare from AR3296 at 07/2323 UTC. The S1/Minor Storm threshold is now expected to be reached soon after 08/1200 UTC, with a tentative end timing of 09/1200 UTC, although this may be revised. Elevated proton levels should continue into 09 May, then falling back to near ambient background levels again by 10 May in the absence of any further significant flares.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ S1	No	90	60	15	15
Very Active	≥ S3 *	No	3	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

Figure 3: GOES16 Proton Flux



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High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) observed by GOES-16 is at background levels, having been suppressed due to numerous recent CME arrivals at GEO. Electron counts are expected to largely persist at this level through 08-09 May but may increase to diurnally High levels on 10 May as the geospace environment eases following recent geomagnetic activity. The latest Earth-directed CME from 07 May should reduce electron flux either late 10 May or early 11 May, with Background to Moderate levels most likely to occur thereafter.

The associated 24 hour fluence remains well below the Active level and is expected to persist at this level during much of, if not all of the period, with only a very slight chance of briefly reaching Active levels on 10 May ahead of any anticipated CME arrival.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	10	5
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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Figure 4: GOES-16 Electron flux and MOSWOC Fluence forecast

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